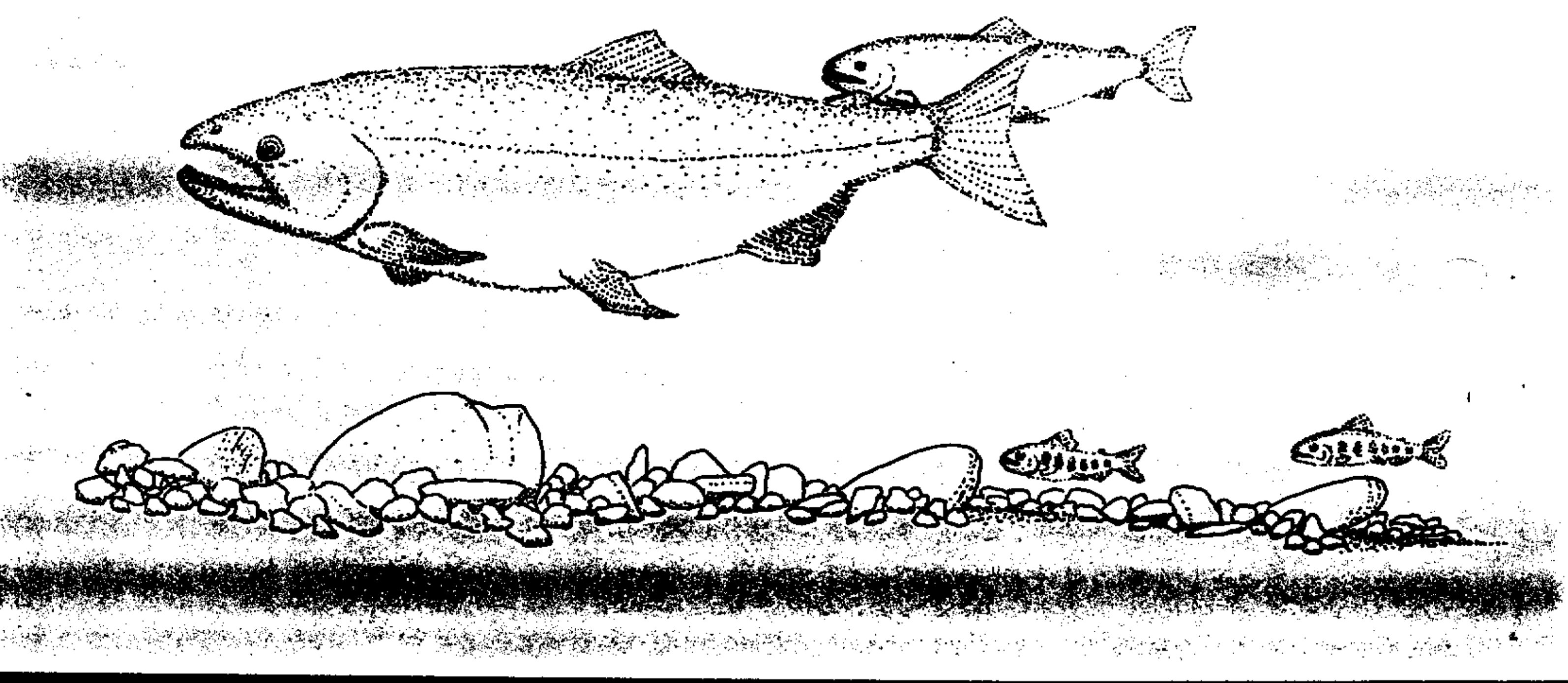
U. S. Fish and Wildlife Service
Fisheries Assistance Office
Olympia, Washington

A CURSORY EVALUATION OF THE EFFECTS OF CODED WIRE TAGGING ON SALMONIDS

June, 1985



A CURSORY EVALUATION OF THE EFFECTS OF CODED WIRE TAGGING UPON SALMONIDS

Prepared by
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U.S. Fish and Wildlife Service
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INTRODUCTION

The technique of coded wire tagging (CWT) has existed since 1963 (Jefferts et al. 1963). The process involves the excision of a fin, usually the adipose, and the injection of a binary coded metal tag into the fishes snout (Figure 13 page 22). Fish as small as 1800/lb can be tagged. The tag remains in the fish throughout its life and can be recovered from the adult. Although many agencies are using this technique for identification of salmonids, work is also being done with other species such as herring and crustaceans.

The U.S. Fish and Wildlife Service (FWS), Region 1, uses the CWT to mark thousands of salmon and steelhead annually. Some FWS biologists believe the process of CWT coupled with its widespread use can cause significant damage to our hatchery production. Damage concerns range from a suspected spread of disease from fish to fish by injection wound (Leek, FWS, personal communication) to increased disease and mortality due to handling stress (Taylor, FWS, personal communication). This report presents available information regarding those concerns.

The groups examined in this report are hatchery stocks that were coded wire tagged according to U.S. Fish and Wildlife, Region 1 Anadromous Fish Tagging Procedures. The conclusions may not apply to wild stock tagging or to other agency tagging programs.

METHODS

The most obvious and verifiable damage done to fish by CWT is immediate death and consequent loss in production. However, potential problems that are more subtle but could still lead to loss in production were considered:

1) On station delayed mortality caused by handling stress.

2) Spread of disease from fish to fish caused by injection.

3) Spread of disease between groups or stations.

4) Reduced adult size.

5) Increased adult straying because of olfactory damage.

6) Off station delayed mortality.

7) Reduced juvenile size.

A literature search for comprehensive CWT reports addressing these potential problems was conducted. A list of the people contacted for reports is included in the Appendix. Reports regarding the components of the CWT process such as handling, anesthesia, fin clipping and injection with a metal tag were reviewed to determine possible effects each step may have upon fish.

In addition to literature reviews information was examined from several groups of CWT fish. The groups reviewed are listed in Table 1. The information collected from these groups included tagging records, health profiles, mortality records, mark sampling data, adult lengths and age data determined from scale analysis. Mark to unmark ratios of releases, mortalities and hatchery returns were determined to address concerns one and six. Age and length data was used to address concern number four and the experiences of other scientists to address the remaining concerns.

ASSUMPTIONS/SOURCES OF VARIABILITY

All of the groups examined were originally tagged for reasons other than to investigate the effects of CWT. It is probably safe to assume that more types of data and perhaps more accurate data would have been collected if the tag groups had been identified as study groups for CWT effects. Specific experimental groups usually receive more attention than production tag groups. It is also understood that the logistics of tracking groups of fish at large hatcheries is difficult. Mortality records are sometimes questionable because of poor enumeration techniques particularly at stations with predation problems. In addition, the number of groups examined was limited because of time. The selection of the fish that were tagged can also cause some variability since tagged fish need to be representative of the unmarked fish in some comparisons.

The assumptions made are:

1) The records of number of marked, number of mortalities, number of releases, numbers of return, age and length are good estimates.

2) The marked fish were representative of the unmarked fish at marking in the groups used to address concerns one, two, four and six.

RESULTS AND DISCUSSION

Literature Review

Even though CWT has existed for about 20 years, few reports were found addressing effects on salmonids. Eames and Hino (1983) found that CWT had no significant effect on growth or survival of juvenile chinook in a lake. Opdycke and Zajac (1980) reported negligible short term mortality caused by the CWT of juvenile chum. Bergman (1968), concluded that juvenile coho that had been CWT but not fin clipped did not suffer from growth or migration changes but did show a reduced survival rate. Bergman et al. (unknown date) report that the presence of a CWT had no significant effect on mortality or growth rate of juvenile salmon in a hatchery situation. Jefferts et al. (1963) CWT juvenile chinook at a research station and found no significant effects upon growth or mortality rates.

Table 1. Groups of fish examined for effects of coded wire tagging.

Hatchery	Species	Brood Year	Tagged or Untagged
Quilcene	Coho	1970-1972	Untagged
		1979-1981	Tagged
	Spring Chinook	1981, 1982	Tagged
Quinault	Coho	1979-1981	Tagged
	Winter Steelhead	1979-1982	Tagged
	Fall Chinook	1978-1981	Tagged
Willard	Coho	1982	Tagged
Makah	Coho	1980	Tagged
Lower Elwha	Coho	1982	Tagged

The number of reports addressing the effects of CWT was limited so the search was extended to include the effects of each step in the CWT process. The steps are handling, anesthesia, fin excision and tag injection. Various authors have reported these steps can cause stress as measured by changes in physiological functions. Wedemeyer (1976), reports juvenile coho subjected to handling and crowding in intensive fish culture may require a week to recover. Wedemeyer (1972), reported that "mild handling" (dipnetting), caused metabolic and osmoregulatory changes in juvenile coho and steelhead that required 24 hours for full recovery.

The use of anesthesia can also cause stress. The FWS is currently using MS-222 for most of its CWT. Wedemeyer (1970) reported rainbow trout were stressed when MS-222 was used. Bouck and Johnson 1979, report anesthitized coho smolts transferred to saltwater pens suffered heavy mortality. However, when the fish were allowed to recover in freshwater before being transferred to saltwater pens, the mortality was reduced. And, finally anesthitized fish not transferred to saltwater at all suffered no mortality. The FWS usually allows sufficient recovery time in freshwater before release or transfer to saltwater.

The third step in the CWT process is fin excision. The adipose fin is the most frequently removed fin. Most biologists agree that various fin removal combinations will reduce growth and cause mortality. Their opinions are supported by the literature. Saunders et al. (1969) concluded that adipose-left ventral marks reduced growth and survival of Atlantic salmon. Weber and Wahle (1969) report reduced survival of adipose-left maxillary marked sockeye. Nicola and Cordone (unknown date) used many fin clips and found that all reduced survival of rainbow trout. However, the adipose clip was least detrimental. Cleaver (1968) concluded that ventral-adipose-maxillary combinations reduced growth and survival of juvenile fall chinook. Senn (1970) assumed various ventral-maxillary combinations reduced survival and reports it reduced average adult weight.

Tag injection is the final phase of CWT. Bergman et al. (unknown date) report the puncture wound in the skin healed within 48 hours. The cartilage repaired itself within 14 days and no inflamation of the tissue was noted. Jefferts et al. (1963) report no tissue reaction to the tag.

Examination of tag Groups

1) On station delayed mortality caused by handling stress

The easiest form of CWT damage to identify and enumerate is immediate mortality. There is obviously some loss of fish during the CWT process. Mortality can be caused by crushing against raceway crowding screens or by excessive exposure to the anesthetic. However, the direct mortality is negligible if correct CWT procedures are used. In fact, the loss is no worse than that accrued during standard hatchery operating procedures such as raceway cleaning, spliting, and sampling.

Delayed mortality on the station because of handling is another concern. According to the literature there is stress involved during all phases of CWT but not necessarily mortality. Mortality curves were developed for several groups CWT fish and one group of unmarked fish. A rise in the curves soon after tagging would be expected if the combined CWT associated stress was causing delayed mortality. The curves are presented in Figures 1 through 6. All curves except one show a leveling off or decrease in the mortality rates several months after tagging. Comparison of the marked group curves to the unmarked group curve shows similarities. The curves are highest during the spring-summer rearing periods and lowest during winter regardless of tagging.

2) Spread of disease from fish to fish because of injection

The concern expressed most often is suspected spread of disease and subsequent death within a group of fish from injection. The preliminary results of a study conducted with a coho population known to carry kidney disease at the Lower Elwha Hatchery, indicate no disease spread or increase caused by CWT (Zajac, Brunson, Gilliam, and Comstock, report in preparation). However Steve Leek (FWS, personal communication) has documented lower return rates of marked than unmarked spring chinook when the marking was done during a known kidney disease outbreak. When the same species (known kidney disease carrier) was tagged during a relatively healthy period of their life, the return rates of marked and unmarked fish were the same. This indicates that the injection either spread the disease by the open wound or from bacteria on the needle to healthy fish or stressed the injected fish enough to escalate the disease development. Leek believes that this may happen with other diseases as well. This theory was investigated by comparing mark percentages after tagging to mark percentage of mortalities until release. This was done with groups documented as being healthy at the time of marking and with groups that were known to be sick at marking. The rates should be similar if the injection had a negligible effect. Figures 7 through 11 present data from groups that were relatively healthy at tagging. In general, the mortality figures during tagging were low for all of these groups. Approximately half of these groups show negligible difference between the percent mortality of marked and unmarked groups. The remaining half show differences, but in no consistent direction. This may indicate that poor estimates of mortality, or group size were used or perhaps the marked fish were not representative of the unmarked fish. The information from these healthy groups indicates negligible damage caused by injection.

Figure 12 presents the ratio of marked fish in the population to the marked mortalities from multiple groups of tagged Willard coho. These coho were not healthy at tagging and suffered very high mortality of both marked and unmarked fish. Approximately half of these groups display similar ratios indicating that the injection itself did no further damage. However, the remaining half displays significantly higher percentages of marked fish in the mortalities. This indicates substantial damage was done to these fish by injection. However, it is not known if the mortalities were caused by the additional stress of injection or if the injection spread disease to healthy fish. It is obvious that these fish should not have been tagged.

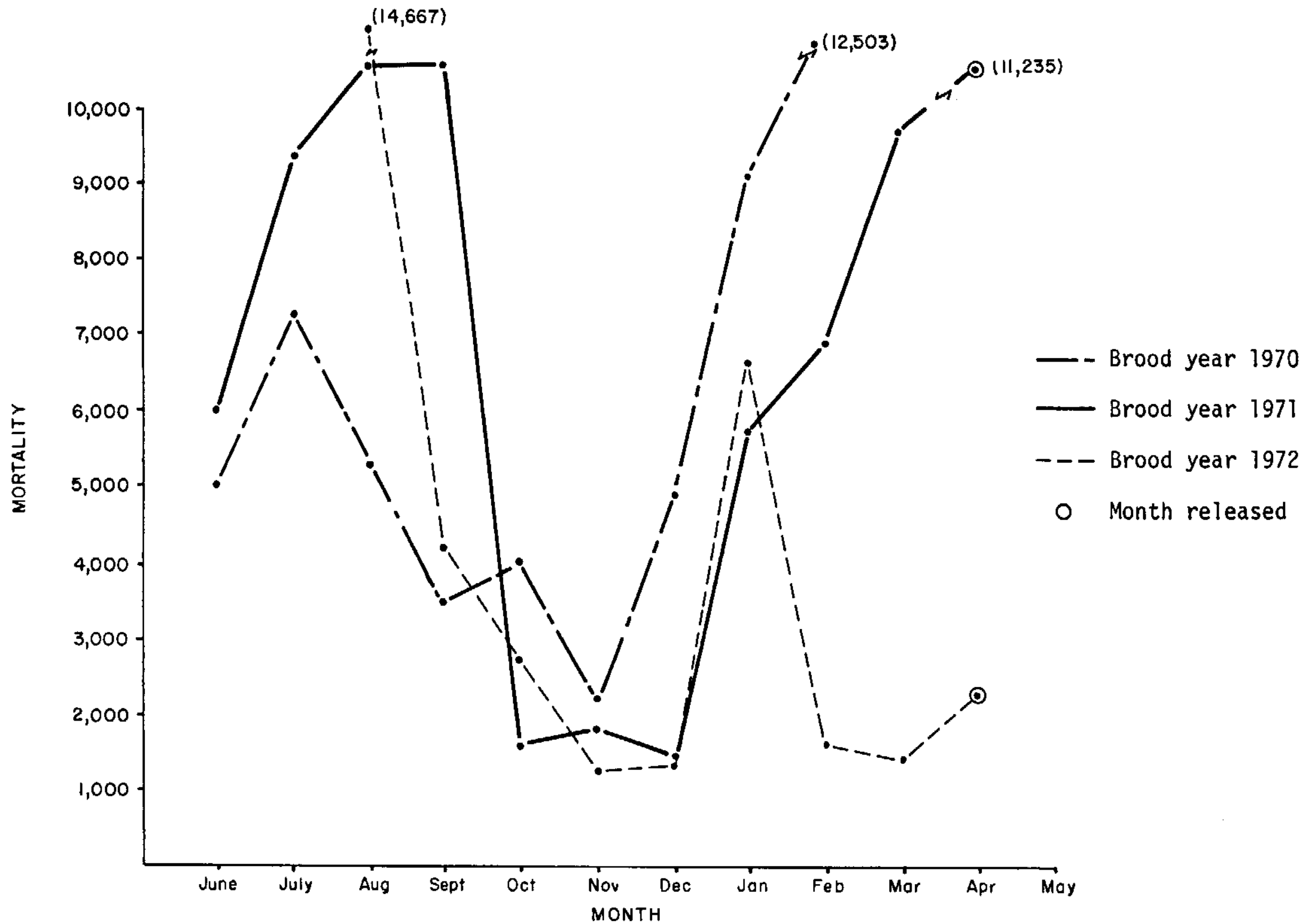

Figure 1. Monthly mortality totals of Quilcene Coho groups that were not tagged. The mortality during January for brood year 1972 is an inventory adjustment figure, not an actual count.

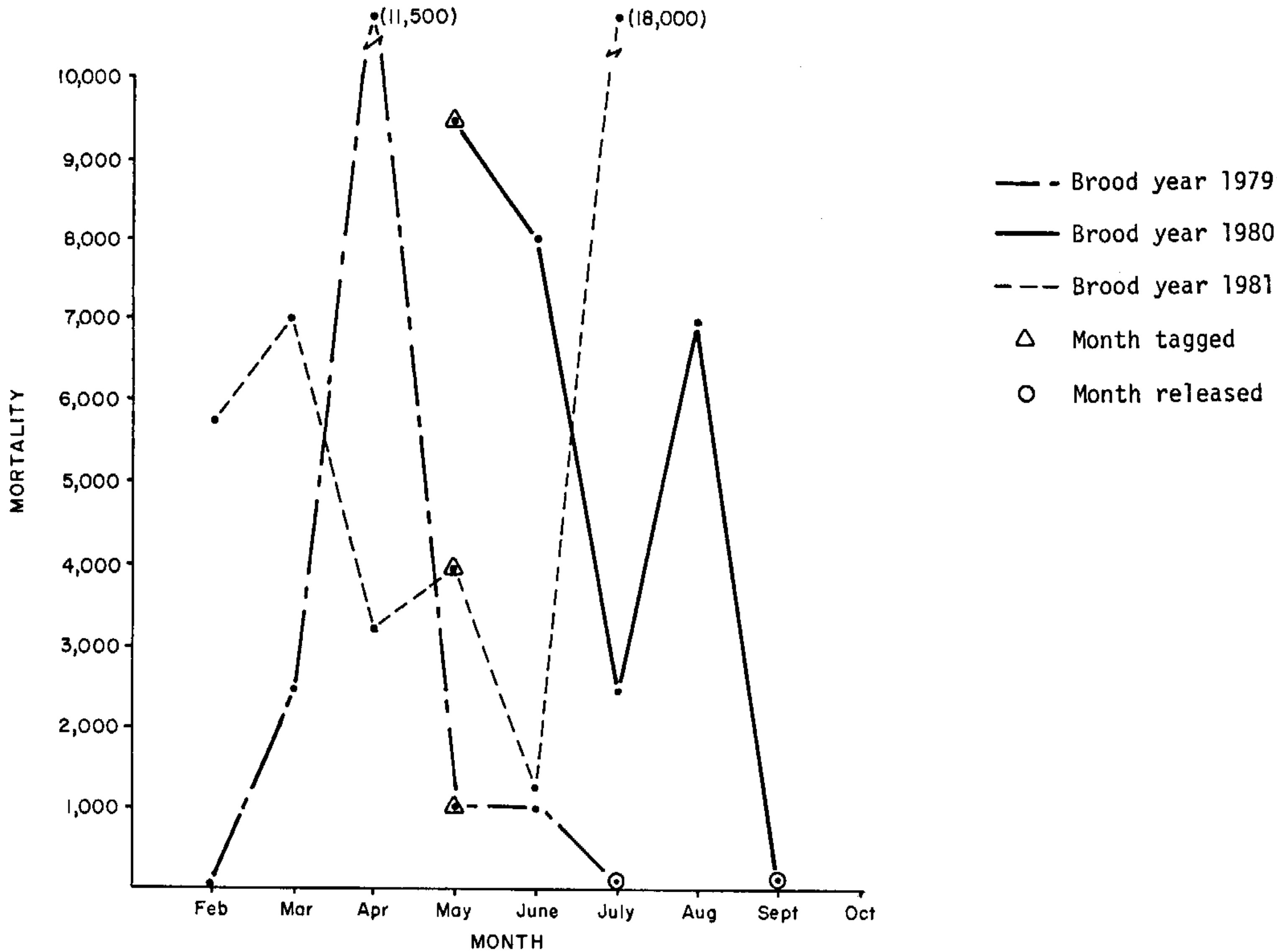

Figure 2. Monthly mortality totals (tagged plus untagged) of Quinault fall Chinook groups. The monthly mortality of brood year 1980 have all been divided by two so they would fit on the graph.

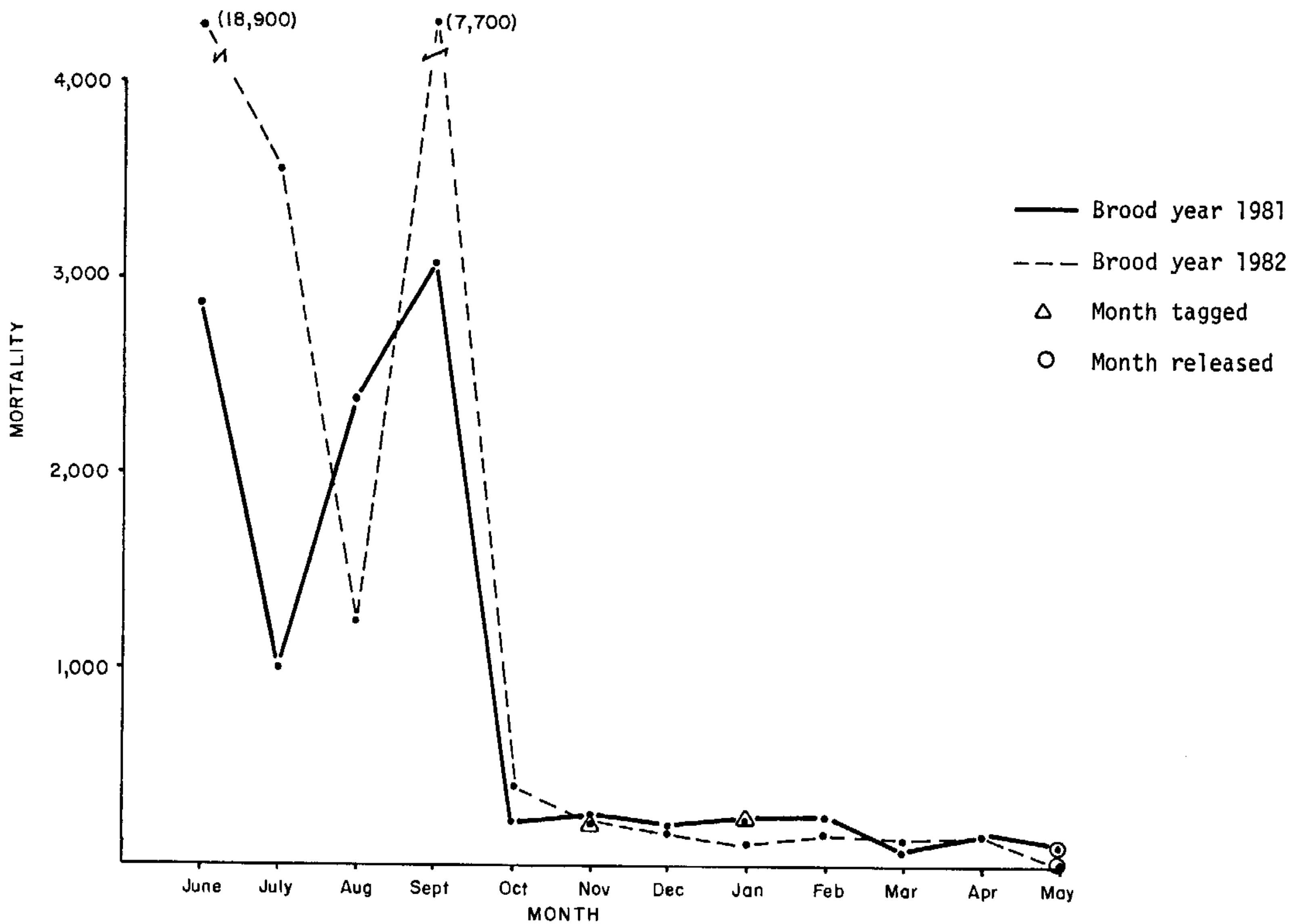

Figure 3. Monthly mortality totals (tagged plus untagged) of Quinault winter steelhead groups.

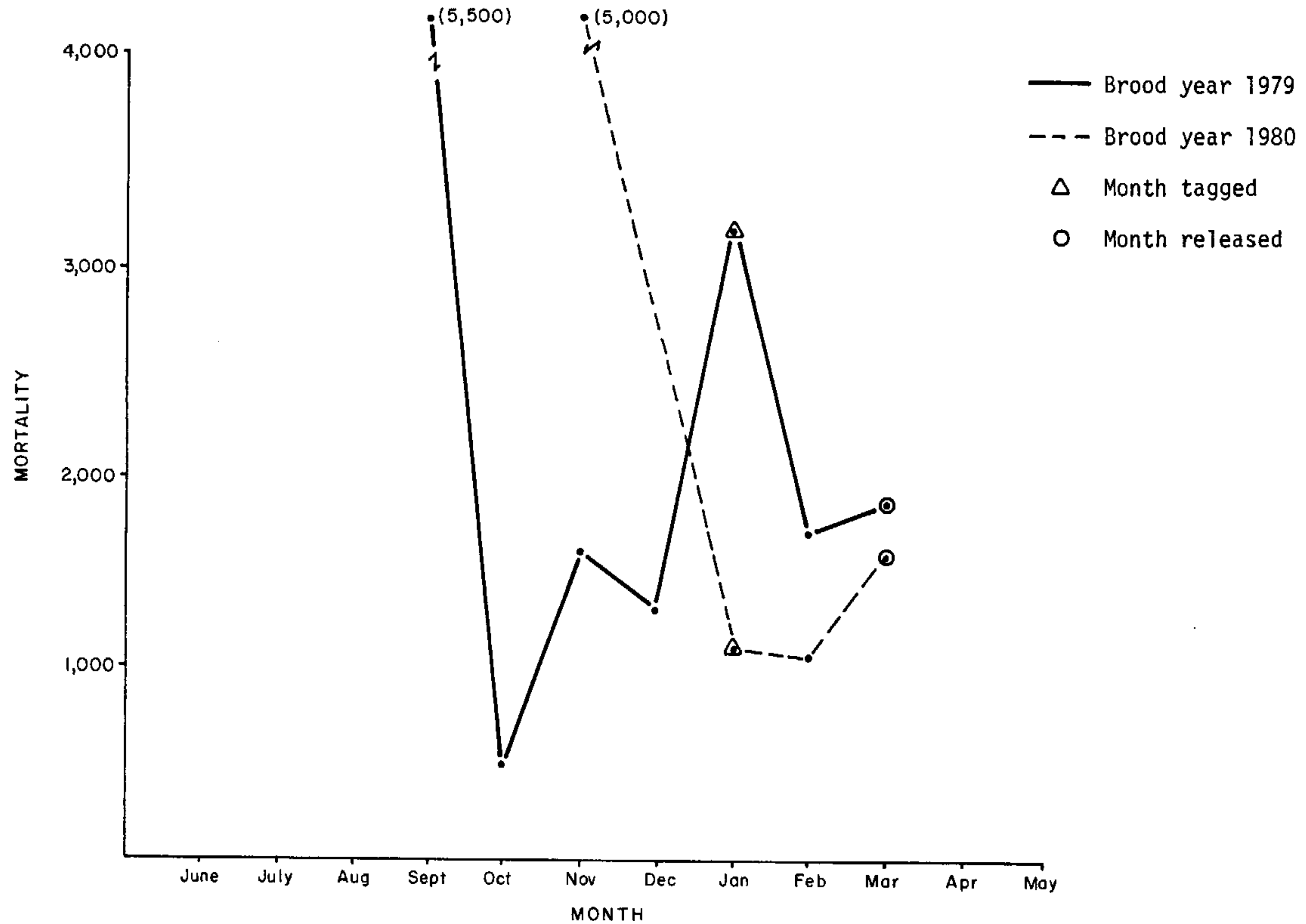

Figure 4. Monthly mortality totals (tagged plus untagged) of Quinault Coho groups.

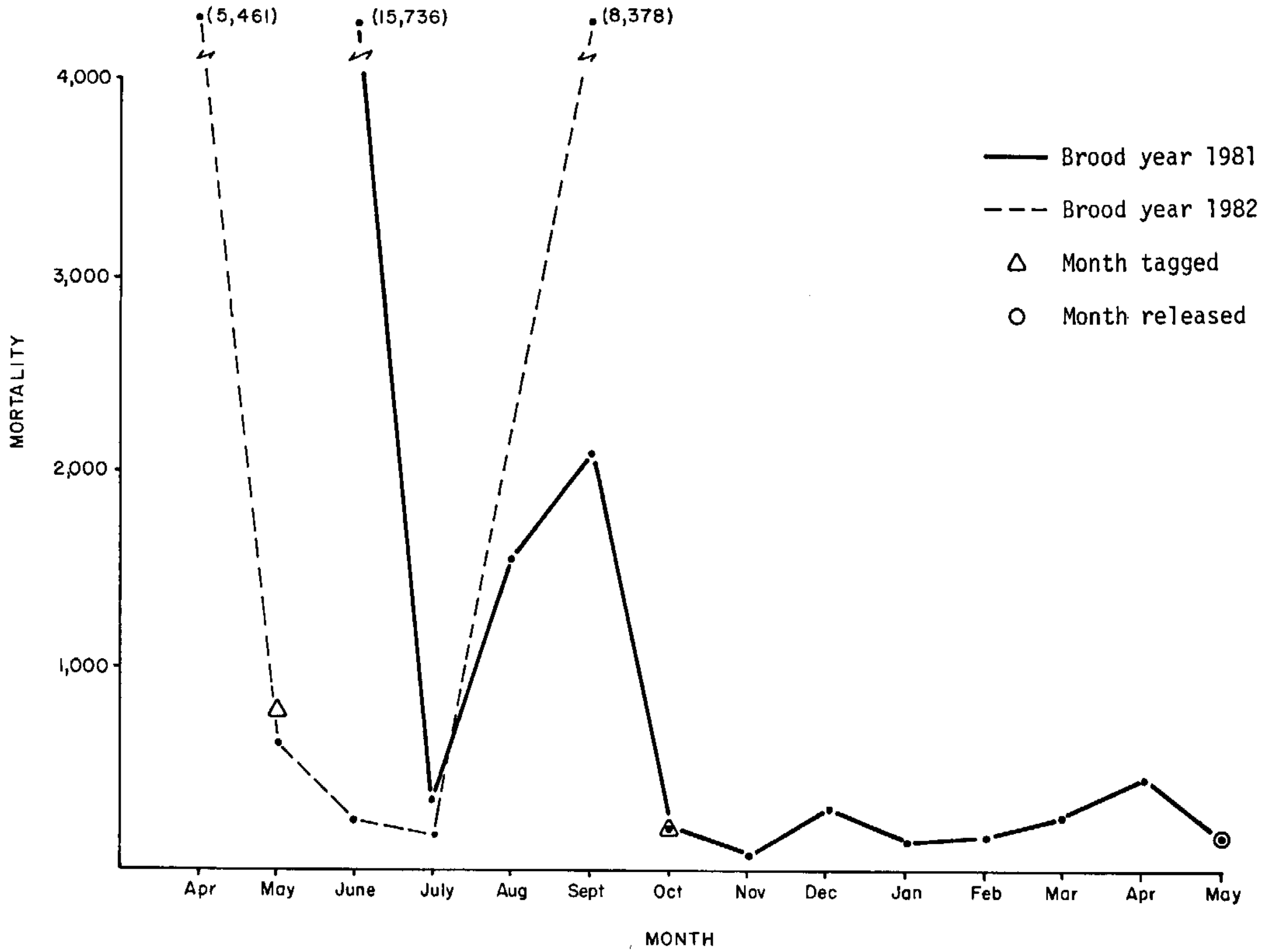

Figure 5. Monthly mortality totals (tagged plus untagged) of Quilcene spring Chinook groups.

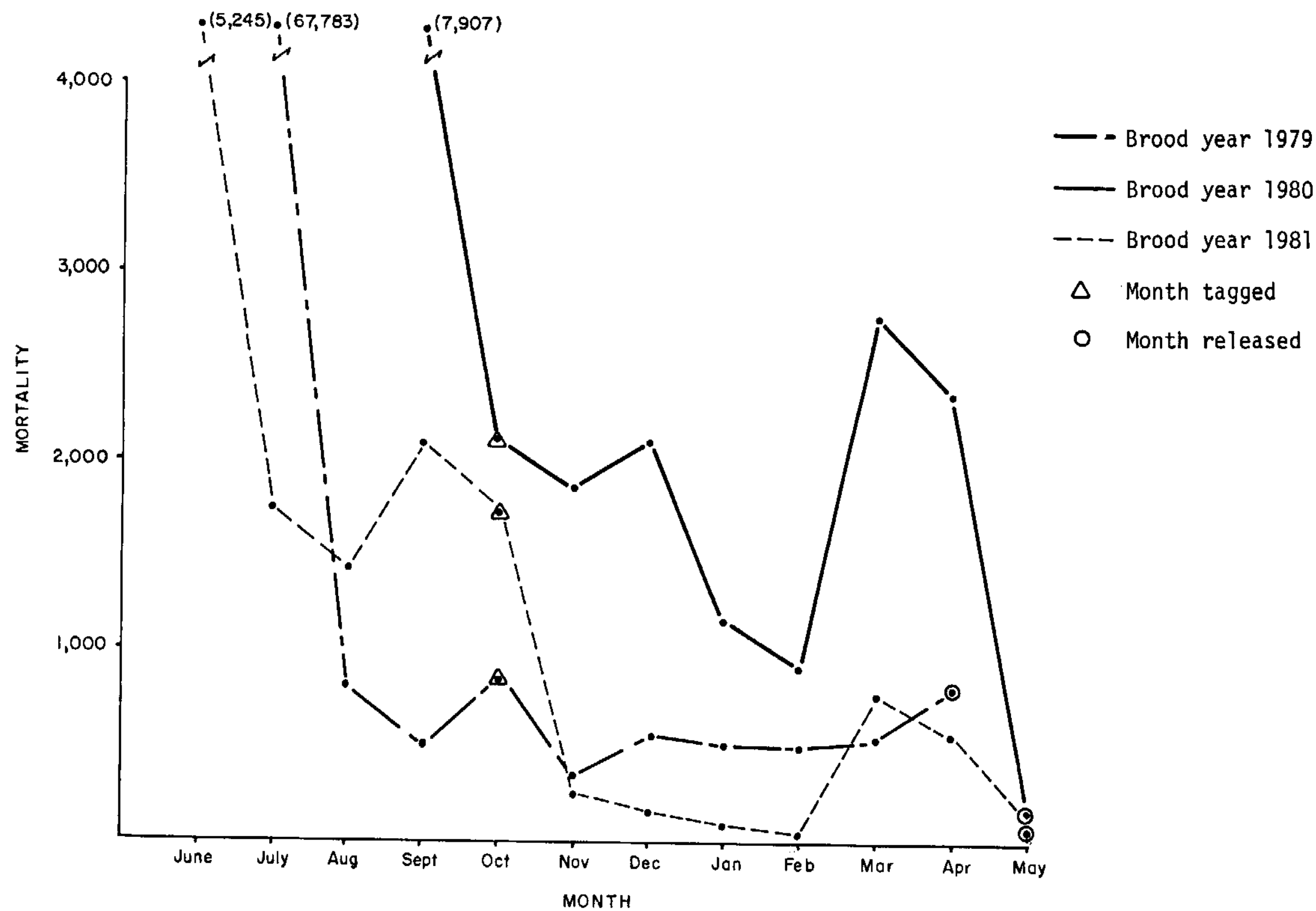

Figure 6. Monthly mortality totals (tagged plus untagged) of Quilcene Coho groups. The mortality in July of the 1979 brood year was due to a raceway wall collapse.

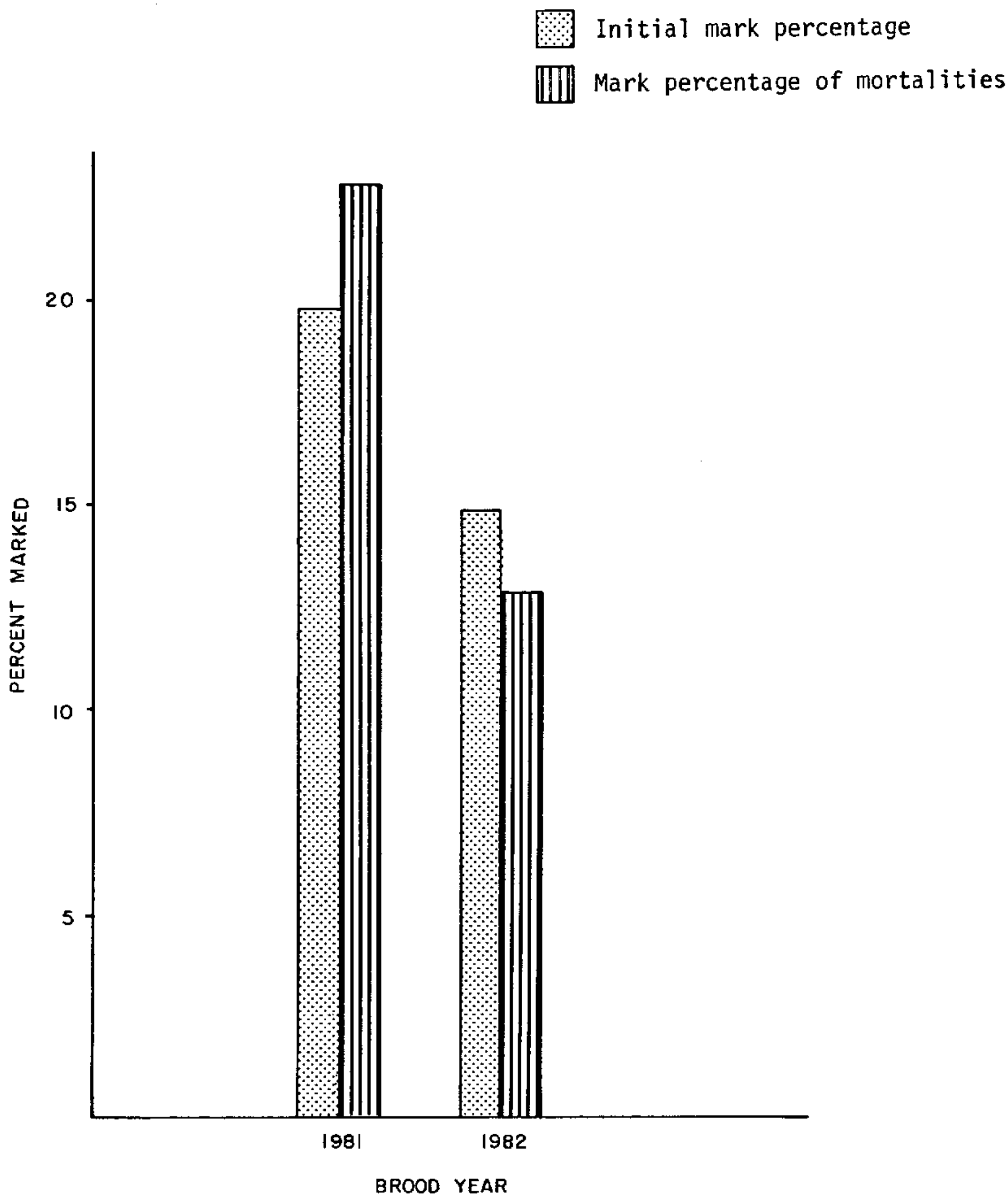

Figure 7. Comparison of mark percentage of groups at tagging versus mark percentage of mortalities until release of Quilcene spring Chinook. These fish were relatively healthy throughout rearing.

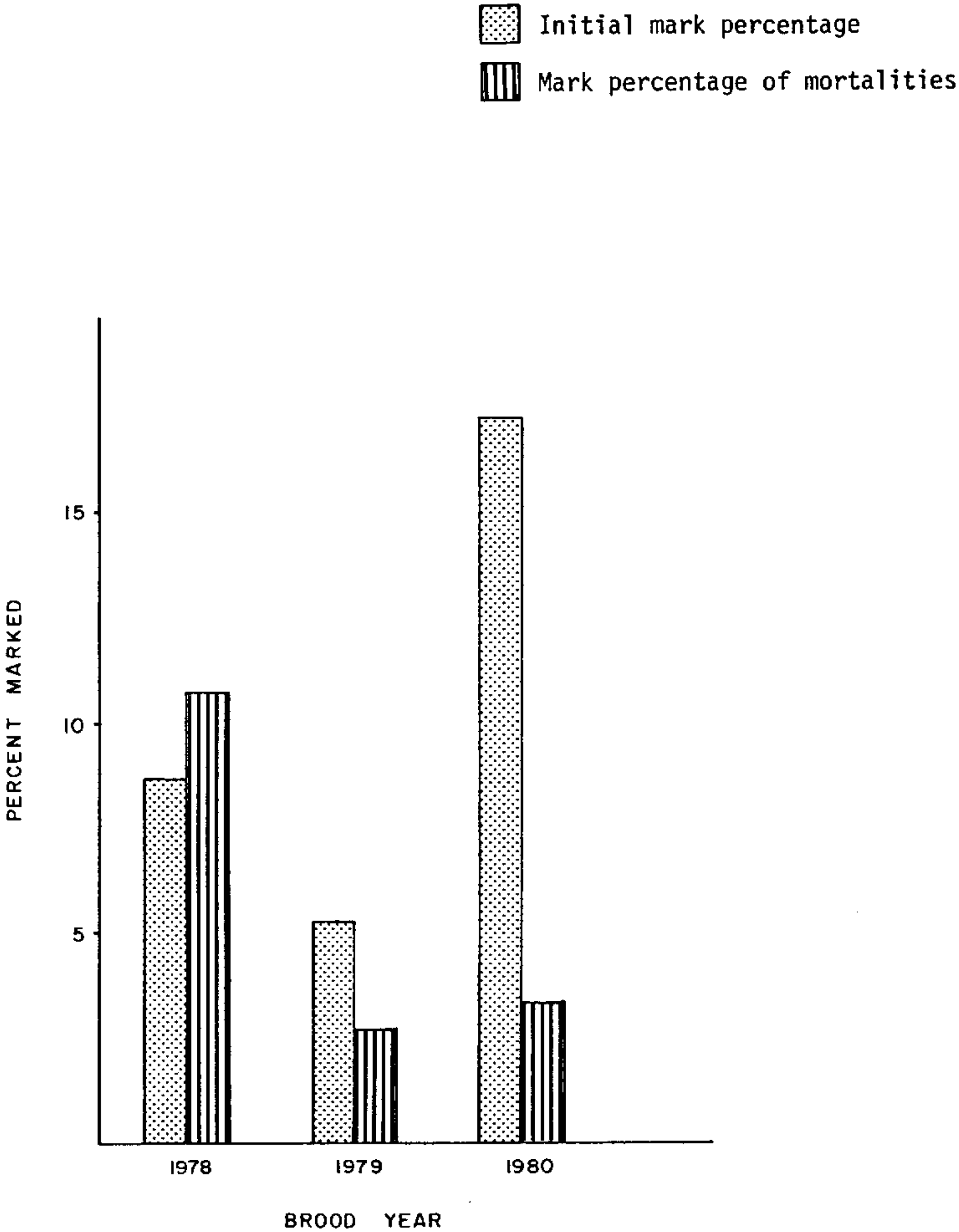

Figure 8. Comparison of mark percentage of groups at tagging versus mark percentage of mortalities until release of Quinault fall Chinook. These fish were relatively healthy throughout rearing.

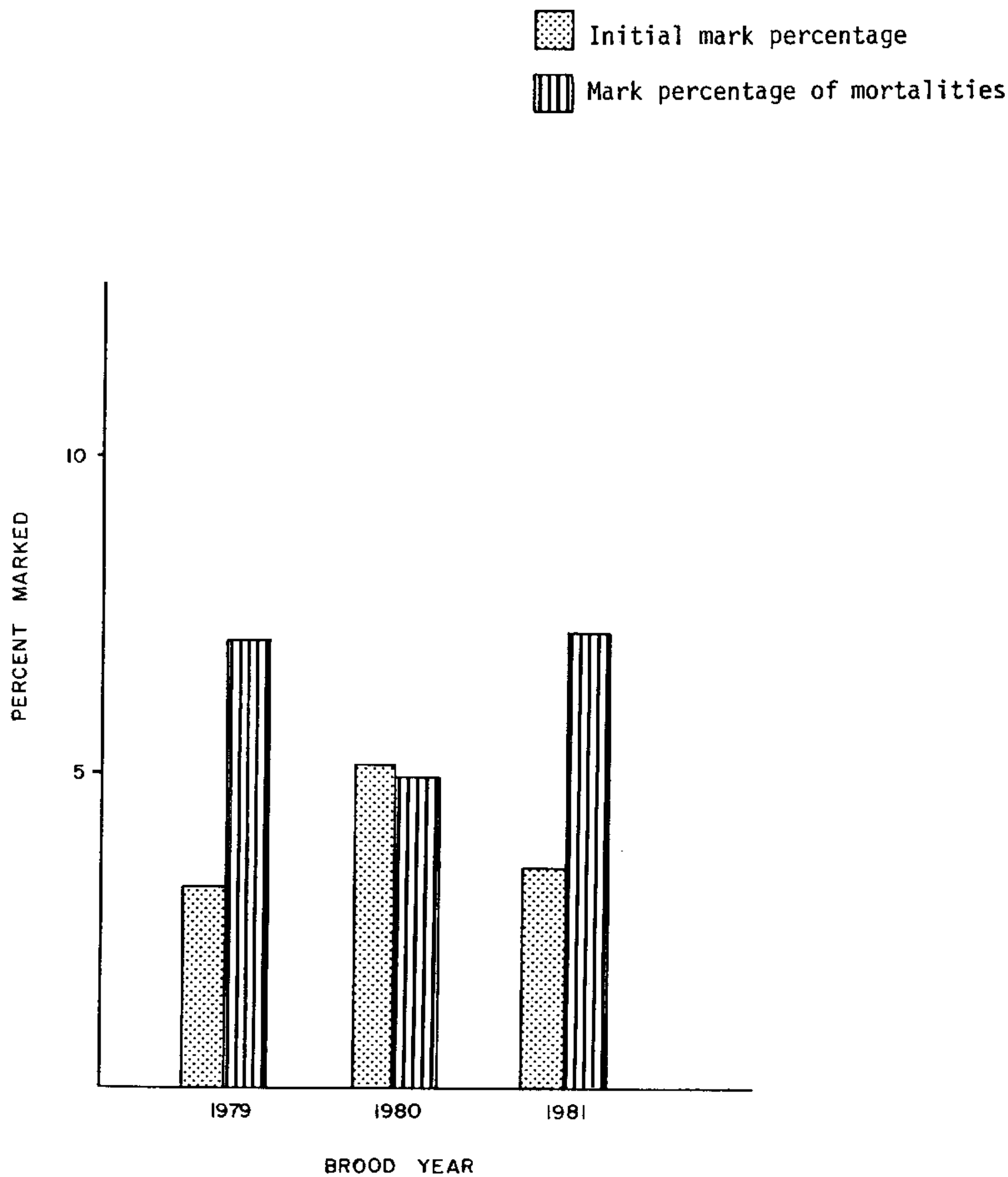

Figure 9. Comparison of mark percentage of groups at tagging versus mark percentage of mortalities until release of Quinault Coho. These fish were relatively healthy throughout rearing.

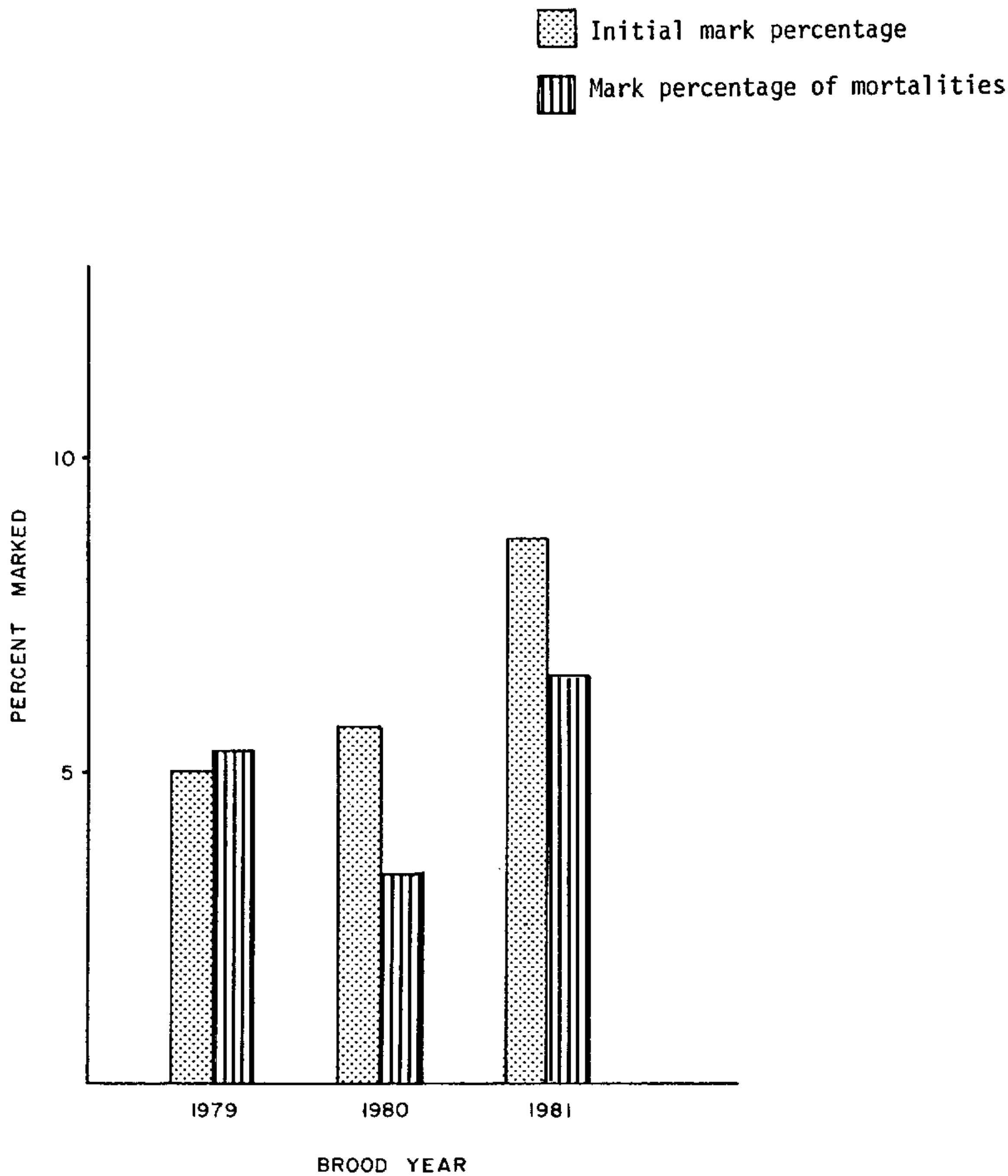

Figure 10. Comparison of mark percentage of groups at tagging versus mark percentage of mortalities until release of Quilcene Coho. These fish were relatively healthy throughout rearing.

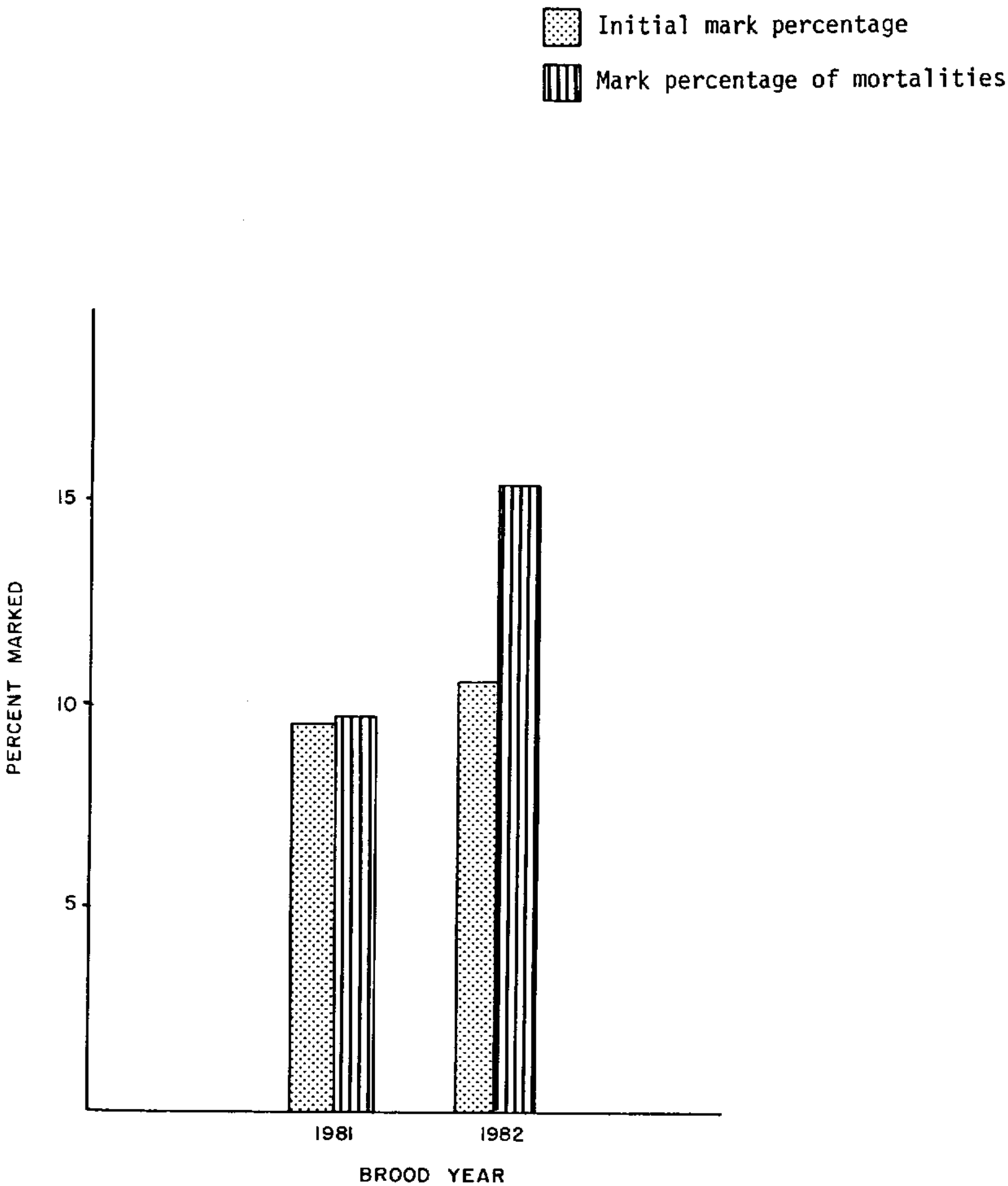

Figure 11. Comparison of mark percentage of groups at tagging versus mark percentage of mortalities until release of Quinault steelhead. These fish were relatively healthy throughout rearing.

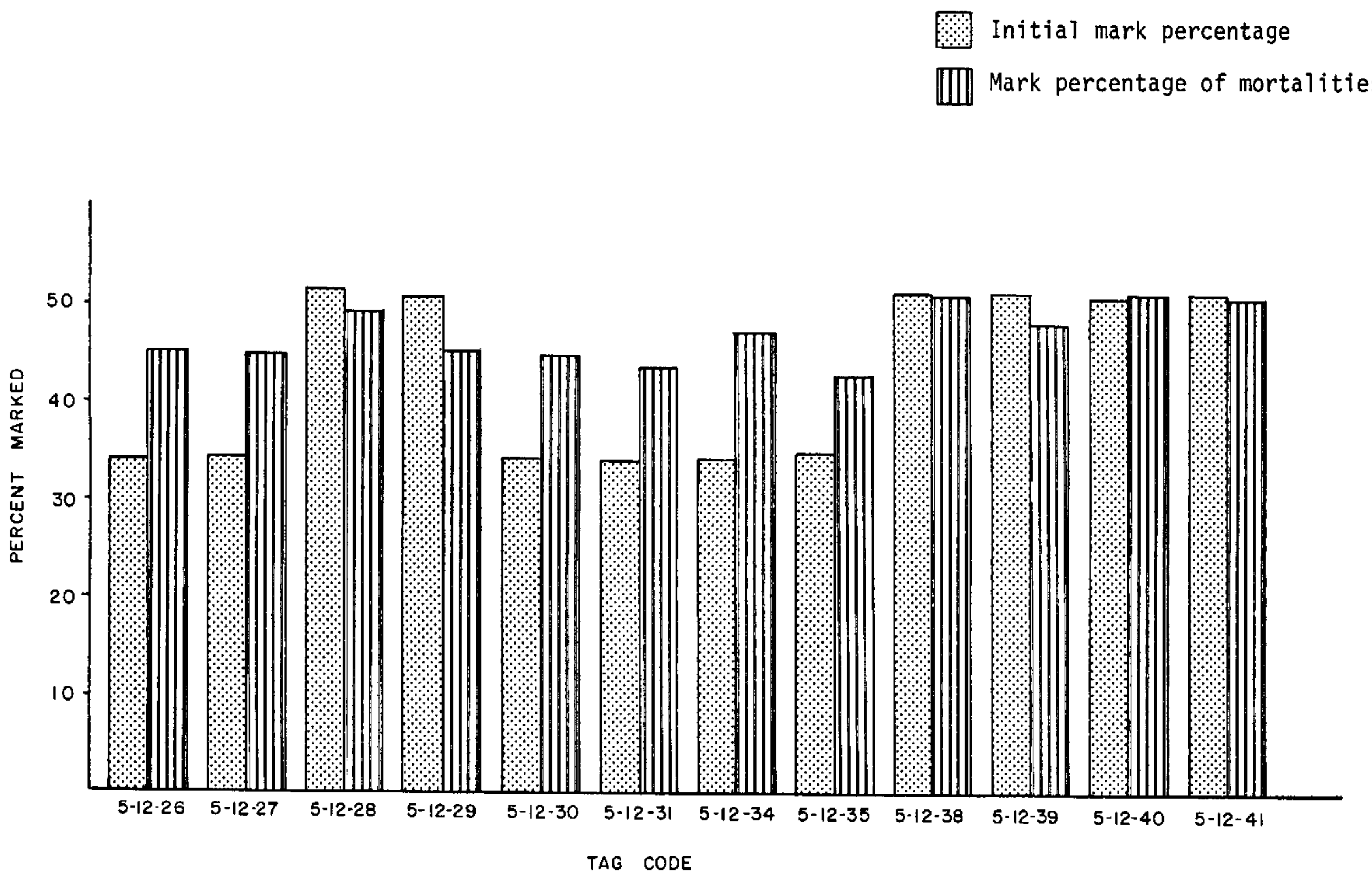

Figure 12. Comparison of mark percentage of groups at tagging versus mark percentage of mortalities until release of 1982 brood year for Willard Coho. These fish had serious outbreaks of Bacterial Kidney Disease and Coldwater Disease before, during and after tagging. Mortalities were very high.

3) Spread of disease between groups or stations

The spread of disease from group to group or hatchery to hatchery is a very serious threat to hatchery production. The tagging program probably represents a significant risk. However, we are very aware of this potential problem with the FWS tagging program. Consequently the FWS Region 1, CWT procedure manual contains a section regarding disinfection. Also, each FWS program uses rigorous disinfection prodecures to prevent the spread of disease. And, as a final precaution FWS pathologists are frequently consulted for development of improved disinfection techniques or for assistance in special cases.

4) Reduced adult size

Loss in hatchery production may not be limited to juvenile or adult mortality. It is possible that the stress caused by CWT can effect the growth rate of marked fish after release. This could mean smaller adult sizes and therefore loss in pounds of returning production. Fork lengths of three groups of Quinault winter steelhead were compared (Table 2). Normally, weights are not measured. Differences in average length are assumed to reflect average weights. Only one of the groups showed a difference in length between the marked and unmarked fish and that was only one centimeter which is negligible. Apparently the CWT had no significant impact on the adult size of these groups. Also Seiler et al. (1981) report no significant difference in mean length between CWT and unmarked coho returning to Sunset Falls on the South Fork Skykomish River in 1979 and Deschutes River in 1978. They also report that CWT male coho were significantly larger than unmarked males returning to Big Beef Creek in 1978. However, they found the CWT females to be smaller than unmarked females. In 1979 the CWT females were larger than unmarked males. This would indicate no length differences caused by CWT.

5) Increased adult straying because of olfactory damage

John Morrison, at the Abernathy Salmon Technology Center is currently examining various groups of CWT juvenile salmon and steelhead for tissue damage.

Preliminary results with CWT spring chinook salmon from Carson NFH (tagged when approx. 60/lb) shows mechanically induced hemorrhage, followed by minor inflammation. At 10 days post tagging, the inflammatory response is subsiding. Further examination at monthly intervals (up to 130 days) has shown no additional tissue reaction to tags. (Morrison, FWS, personal communication).

Morrison has also noticed considerable variation in tag placement. It was estimated that tags were correctly placed in about 40% of 70 tagged spring chinook examined from Carson NFH. Ideal tag placement (Figure 13) is not always possible. Misplacment can be caused by incorrect machine adjustment, operator error or variation of fish size. Tags have been found in or protruding into the fibrous connective tissue of the olfactory bulb. This connective tissue contains nerve fibers from the sensory epithlium.

Table 2. Comparison of average adult lengths of Quinault winter steelhead.

Brood Year	Age	Fork Length (cm) Marked	Fork Length (cm) Unmarked
1979	3	64	64
1979	4	80	79
1981	3	63	63

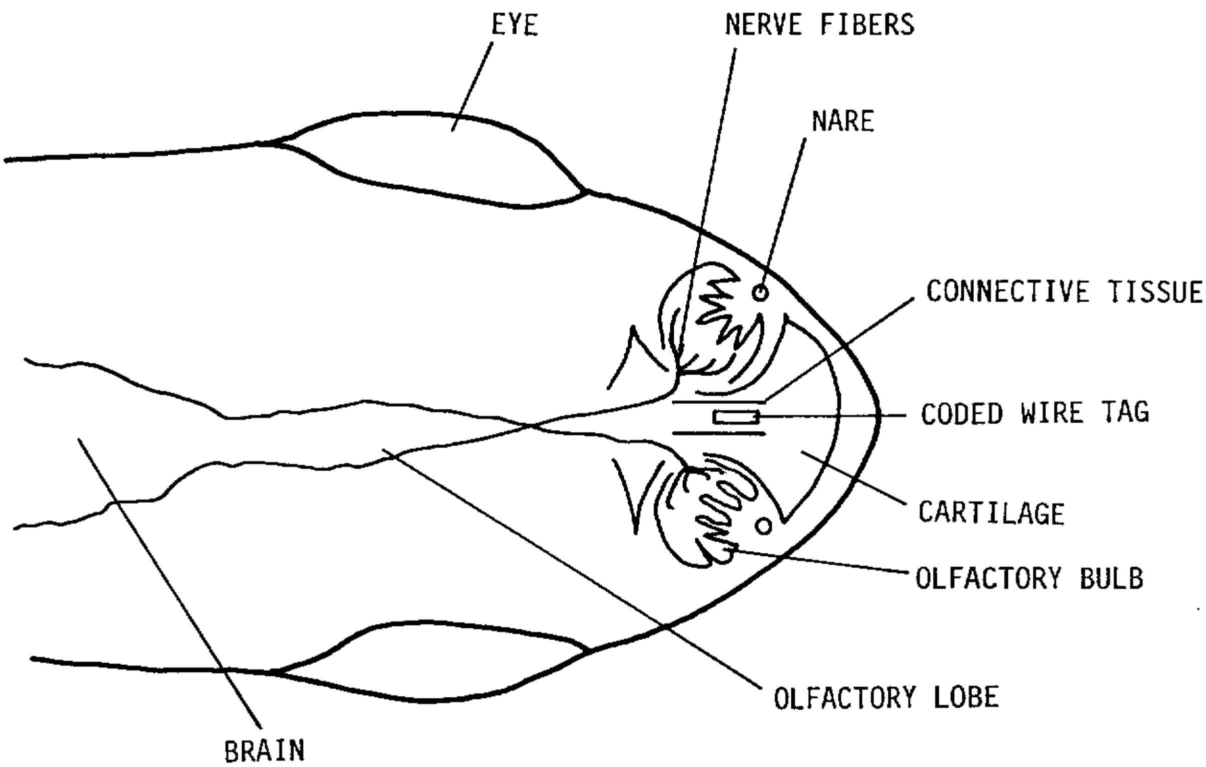

Figure 13. Diagram of fishes snout.

These fibers eventually join laterally to form the main olfactory nerves. In some fish, tag placement in this area has caused degeneration and atrophy of nerve fibers. Although undesireable tag placement does not kill fish, nerve damage could impede olfaction and possibly homing.

Hasler and Scholz (1983) and other scientists report that blockage of the olfactory system interferes with homing ability. They conclude the olfactory system is necessary for correct homing. Therefore, it is possible that olfactory system damage could cause increased straying of adults. Recoveries of CWT show that straying is occurring now. Whether or not it is occurring at rates greater than under natural conditions because of CWT, is not known. Hasler and Scholz (1983) suggest that straying is natural and is important for some genetic exchange to occur. However, there must be a limit to the amount of straying a specific gene pool can tolerate. Morrison's work does show some olfactory system damage although, we do not know if it is sufficient to cause straying.

6) Off station delayed mortality.

Does the CWT process reduce a fishes ability to survive after release into the natural environment? Mark percentages at release and at return were compared to address this question. If the marked fish were representative of the unmarked fish then the mark percentage at release and return would be the same unless the CWT had an effect after release. The groups examined are presented in Figures 14 through 17. Six of the eight groups show negligible differences between the ratios. This indicates the CWT did not cause additional mortality after release. However, the two remaining groups (Figure 17) show a significant difference. Possible reasons for this difference are:

1) Delayed mortality caused by the CWT.

2) Poor estimates of numbers at release.

3) Unrecognizable adipose clips at return.

7) Reduced juvenile size

The available literature reports CWT has no effect on juvenile growth rates (Eames and Hino, 1983; Bergman, 1968; Bergman et al., unknown date; and Jefferts et al. 1963). Juvenile length data was not available for comparison. A difference in growth rate is of no concern unless it manifests itself as post release mortality, reduced adult size or changes age at maturation of the adults. 1/ No adult length differences were found. The majority of the data reviewed in this report indicates no difference in post release mortality between marked and unmarked fish. Also during the construction of graphs comparing mark percentages at release to mark percentage at return very similar percentages in all ages of specific broods were found. This implies there was no change in age structure. If there was a difference in growth rate between marked and unmarked juveniles of the groups examined, it had no permanent detrimental effect.

1/ Biologists generally believe the size and age at release of juveniles can effect survival rates and possibly age at maturation of adults.

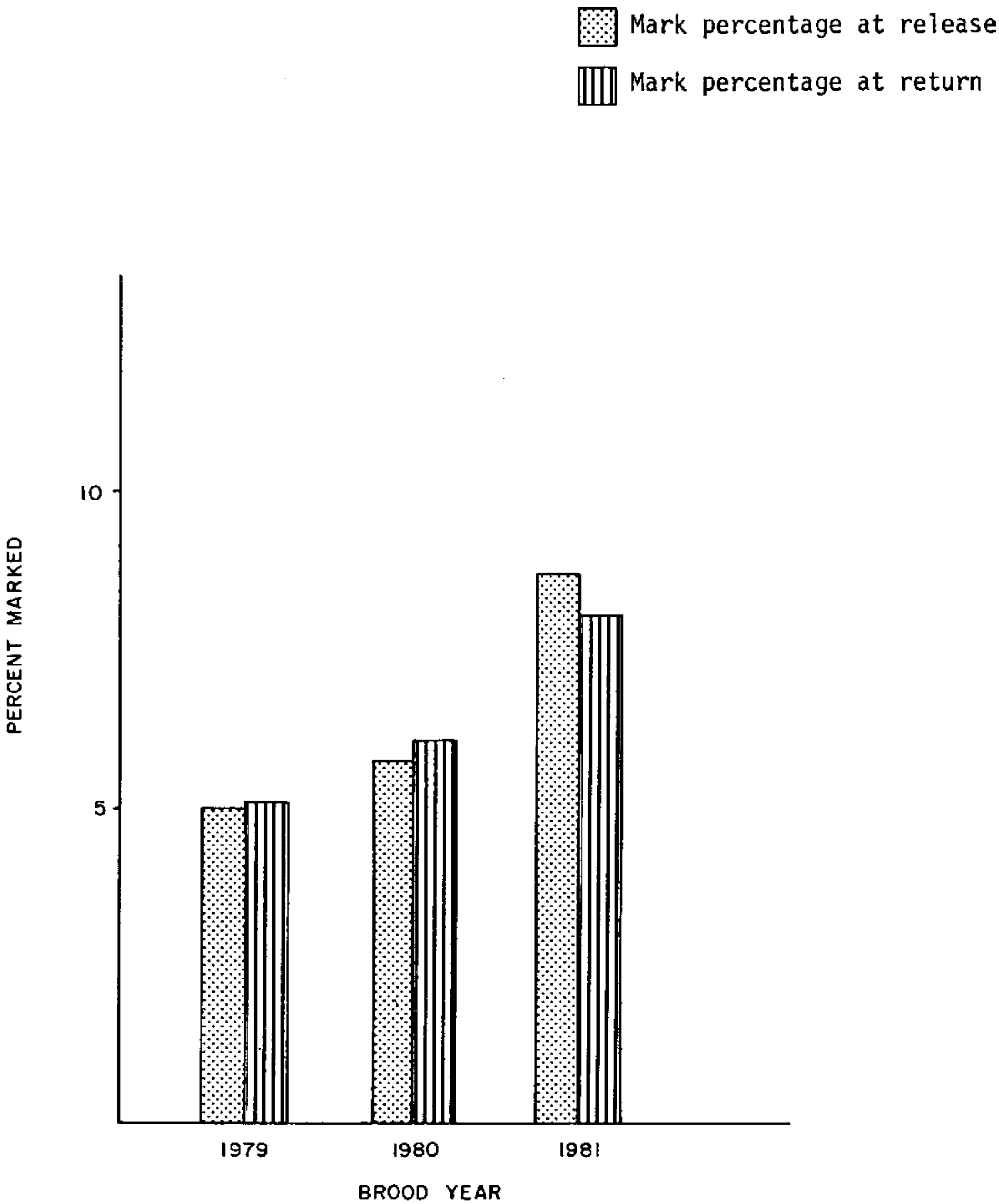

Figure 14. Comparison of mark percentage at release versus mark percentage at return to hatchery of Quilcene Coho.

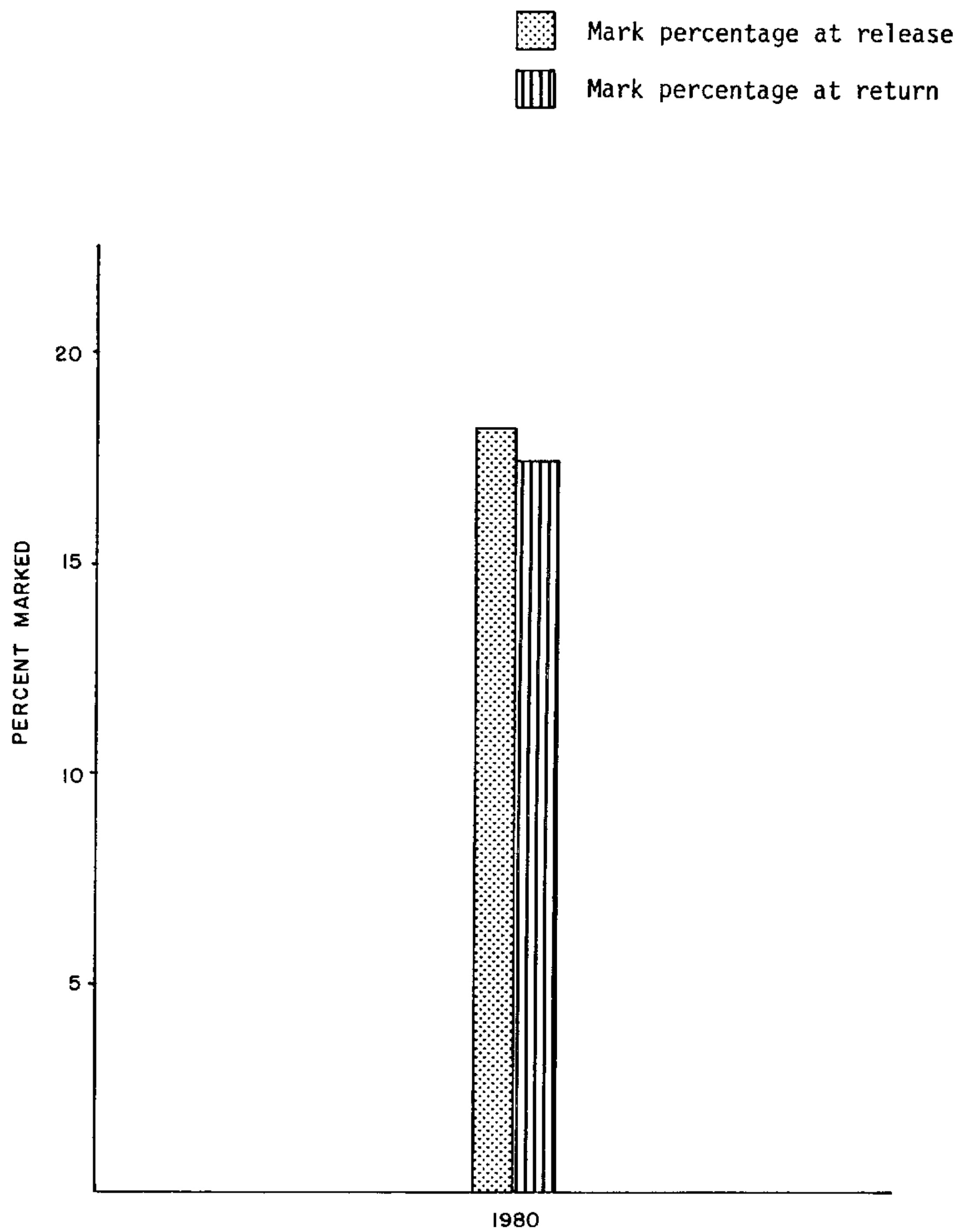

Figure 15. Comparison of mark percentage of release versus mark percentage at return to hatchery of 1980 brood year, Makah Coho.

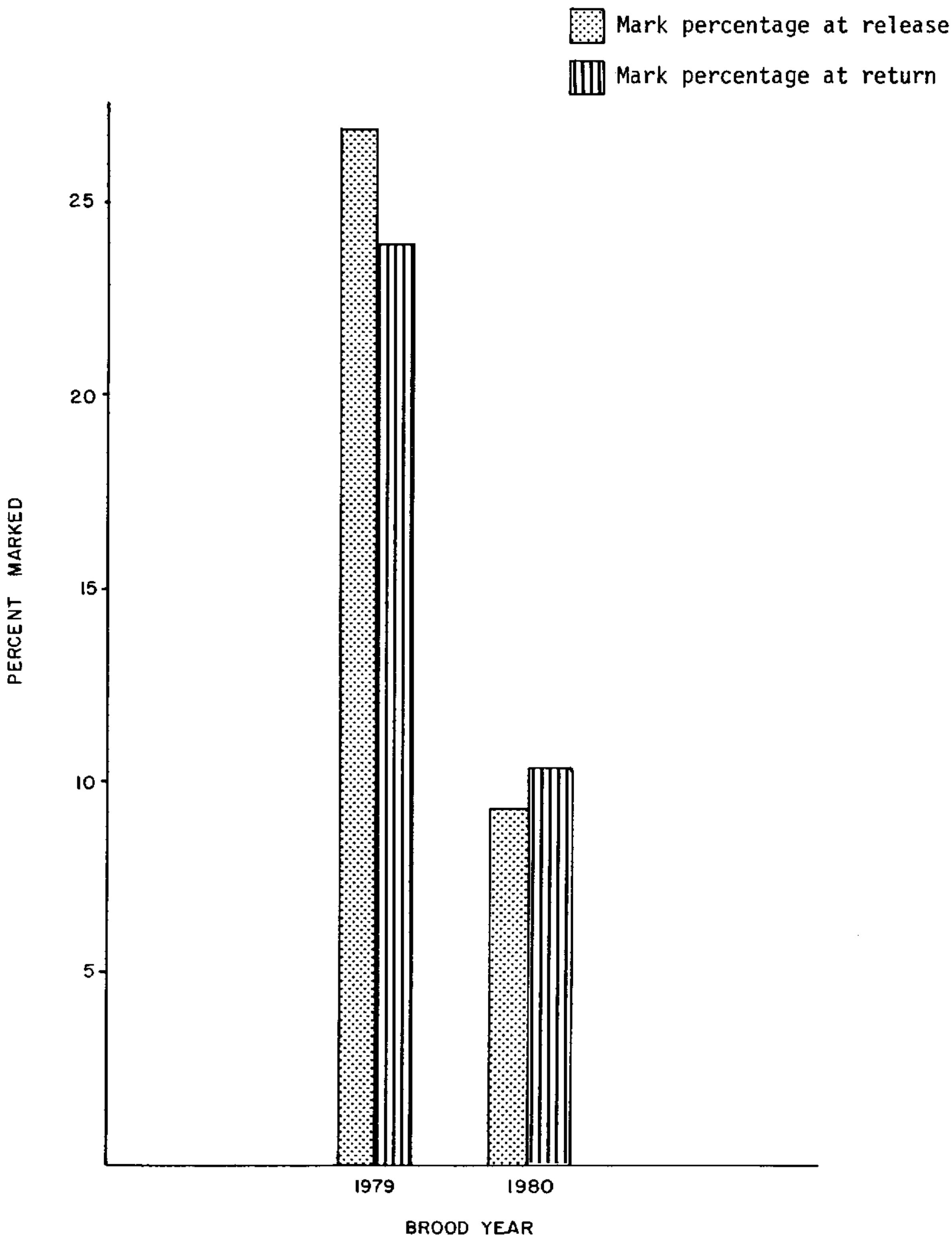

Figure 16. Comparison of mark percentage at release versus mark percentage at return to hatchery of Quinault winter steelhead.

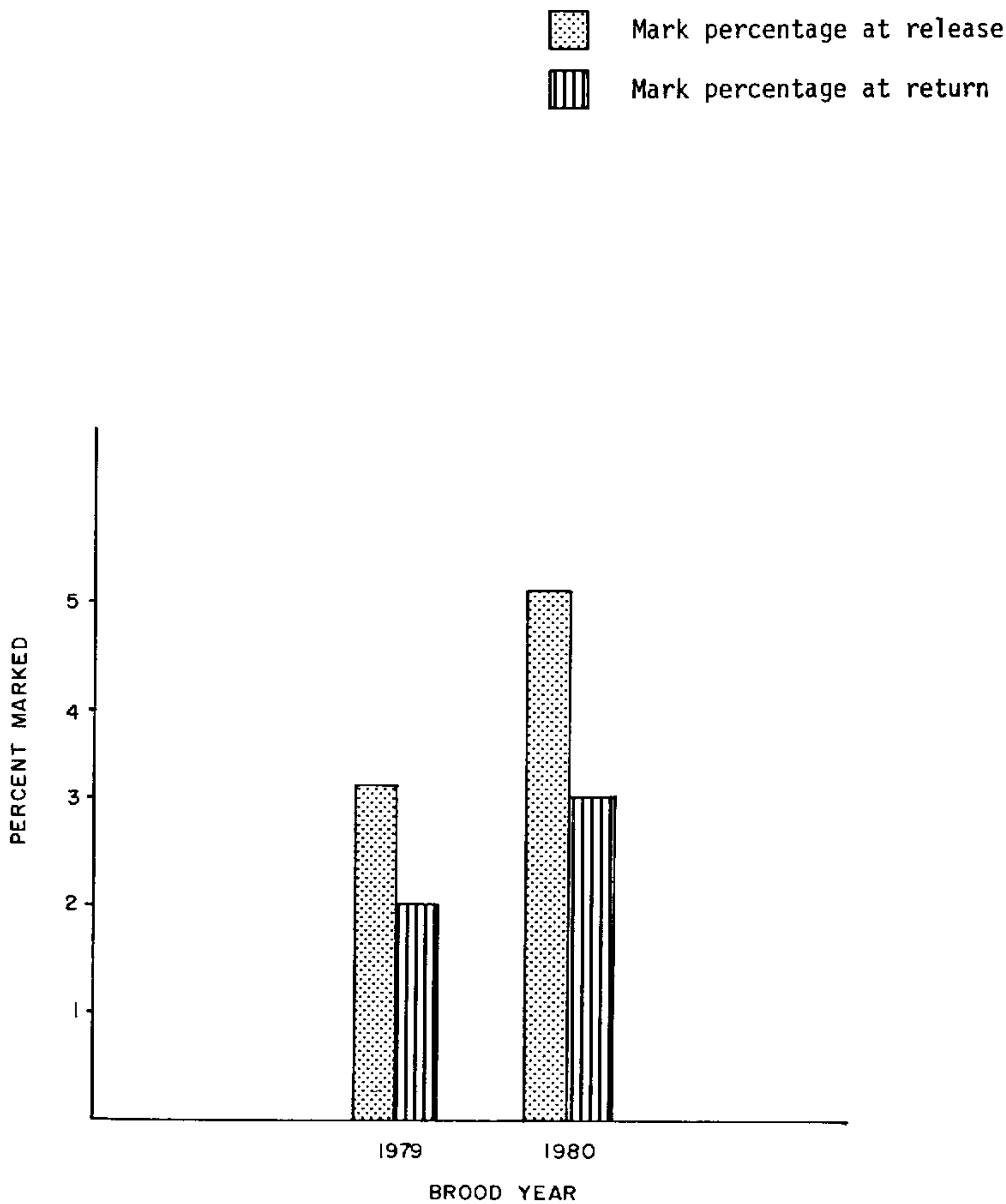

Figure 17. Comparison of mark percentage at release versus mark percentage at return to hatchery of Quinault Coho.

CONCLUSIONS

1) The overwhelming majority of the literature indicates the individual steps of the CWT process can cause stress but probably not significant or permanent damage. The handling and anesthesia of fish are apparently the most often studied components of the CWT process. Stress measured by physiological changes is well documented but the fish recover in a few hours. Very little literature is available concerning injection or adipose clipping. However the literature reports fast healing of the puncture wound.

2) Evidence presented in this review indicates that coded wire tagging of healthy groups of fish does not cause significant on station mortality. Conversely tagging of unhealthy groups will likely cause high mortality. However, it is unclear if the high mortality is caused specifically by tagging stress or by spread of disease from injection. Regardless of the specific mechanism, unhealthy groups of fish should not be tagged.

3) The spread of disease from group to group and station to station is a real threat. Rigorous disinfection of CWT equipment should be done between all stations. In addition, disinfection should be done between groups on a station if one of the groups is found to be sick.

4) Coded wire tagging did not affect the average adult size of the groups examined.

5) Incorrect placement of the CWT can result in physical damage to the olfactory system. This damage may result in increased straying.

6) Tagging did not cause additional mortality after release in the groups reviewed.

7) Coded wire tagging may have caused a change in juvenile growth rate, however it did not appear to result in delayed mortality, decreased size of adults or changes in age at maturity.

RECOMMENDATIONS AND ALTERNATIVES

Proper application of coded wire tags, as defined by the manufacturers and the U.S. Fish and Wildlife Service Region One "Anadromous Fish Tagging Procedures" manual, should not result in increased mortality, spread of pathogens, or reduced size at return. It still remains as the single best tool available for investigations of fish cultural techniques. U.S. Fish and Wildlife Service biologists can improve many aspects of fish production with its use. However the possibility of increased straying caused by olfactory damage should be examined. This work should be performed at a research facility. An evaluation proposed by Dr. Carl Schreck of the cooperative research unit at Oregon State University, may provide additional data needed to evaluate this problem.

One alternative to CWT is the use of other types of marks. However, the other types of tags and marks available either cause more damage to the fish or offer very specific and limited application. Discontinued use of the CWT is another alternative, but seems unreasonable and unwise based on these conclusions and the potential loss of information needed to improve fish cultural techniques. Our CWT experience suggests that CWT is useful and is a relatively harmless tool under controlled conditions and with correct use. Without CWT we cannot make a comprehensive effort to improve our culture techniques, release strategies and therefore our fish production.

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APPENDIX

List of Persons Contacted for CWT Effects Information

Contact

Don Bailey
Tag Coordinator
Canada Dept Fish and Oceans

Lee Blankenship
Tag Coordinator
Washington Dept Fisheries

Karen Crandall
Tag Coordinator
Alaska Dept Fish and Game

Rodney Duke
Tag Coordinator
Idaho Dept Fish and Game

Dennis Isaac
Tag and Mark Coordinator
Oregon Dept Fish and Wildlife

Keith Jefferts
Manufacturer of Coded Wire Tag System

Steve Leek
Pathologist
U.S. Fish and Wildlife Service

Jim Mullan
Project Leader
U.S. Fish and Wildlife Service

Donn Park
Mark Coordinator
National Marine Fish Service

Ron Pelzman
Tag Coordinator
California Dept Fish and Game

Earl Prentice
National Marine Fish Service

Bob Vreeland
Tag Coordinator
National Marine Fish Service